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CONTENTS

Experiments with lime-sulfur, formaldehyde, copper carbonate and chlorophos for the control of covered smuts
Tisdale, W. H., J. W. Taylor and Marion A. Glasscock 163
An improved formaldehyde spray for the onion disease
Anderson, P. J., and A. V. Stoyva 181
The dusting of wheat and oats for smut
Heald, F. D., G. L. Schuster and L. W. Boyer 189
The genus Polystictus and decay of living trees
James R. Weir 194
Phytopathological notes 197
Report of the Fourteenth Annual Meeting of the American Phytopathological Society 198

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PHYTOPATHOLOGY

VOLUME XIII NUMBER 4

APRIL, 1923

EXPERIMENTS WITH HOT WATER, FORMALDEHYDE, COPPER CARBONATE, AND CHLOROPHOL FOR THE CONTROL OF BARLEY SMUTS

W. H. Tisdale, J. W. Taylor and Marion A. Griffiths

INTRODUCTION

The smuts of barley, loose smut caused by *Ustilago nuda* (Jens.) Kell. and Sw., and covered smut caused by *Ustilago hordei* (Pers.) Kell. and Sw., cause considerable annual loss to the barley crop of the United States. According to authoritative investigations the loose smut of barley behaves very much like the loose smut of wheat. It will not be necessary to give a history of these investigations here. An adequate discussion is given by Freeman and Johnson (4) who also report the results of their own studies which confirm the results of previous investigators. The loose smut infects the grain at flowering time or soon afterwards. The spores from smutty heads lodge within the glumes of normal heads when the glumes are open at the flowering period These spores germinate and infect the young ovaries immediately or before they are one-third grown. The fungus remains within the seeds through maturity and until they are sown, when it revives from its state of dormancy as the seeds germinate and grows up through the young plants, causing the abnormal or smutty heads.

Covered smut of barley is similar to bunt of wheat and the smuts of oats, so far as infection is concerned. The smut spores are carried externally or within the glumes on seed from infested fields. Infection takes place through the coleoptile of the young seedlings shortly after the seeds germinate. The fungus grows up through the plant and produces smutty heads. A description of the symptoms of the barley smuts will not be given, due to the fact that they have been adequately described by various authors.

The purpose of this paper is to discuss the results obtained by the use of various seed treatments for the control of these barley smuts. Special consideration has been given the formaldehyde and modified hot-water treatments. The modified hot-water method has been consistently recommended for the control of the loose smuts of barley and

wheat. Jensen (7) devised and used this method in Denmark in 1887; two years later Kellerman and Swingle (9) recommended its use for the control of oat smut in the United States. For the control of covered smut of barley the formaldehyde or other methods of surface sterilization have been recommended. Bolley (2) in 1897 was the first in the United States to recommend the use of formaldehyde for the disinfection of seed grain. Many methods for applying these treatments have been devised since they were introduced. The hot-water method generally has been recommended where the seed is known to carry both loose and covered smuts.

PRESENT INVESTIGATIONS

Modified Hot Water and Formaldehyde

With the hopes of ascertaining more decidedly the limitations of the efficiency of the modified hot-water and formaldehyde treatments for the control of the barley smuts a series of studies was begun by the Office of Cereal Investigations, United States Department of Agriculture, at Arlington Farm, Virginia, in the fall of 1919. Numerous methods of applying hot water and formaldehyde were employed and the treated seed was sown in a rod-row series. At the same time, heavily smutted seed of three varieties of barley, Han River, Tennessee Winter, and Texas Winter, were sown in duplicate in one-fortieth acre plats after being treated as follows:

(1) Presoaked seed 4 to 6 hours in cold water and immersed for 10 minutes in water at 52° C. and spread to dry. A 13-minute dip in hot water (52° C.) generally is recommended (6, 8).

(2) Immersed seed 10 minutes in a formaldehyde solution containing 1 part of a 37- to 40-per cent formaldehyde solution in 320 parts of water, covered overnight and spread to dry. A longer period of soaking has been recommended where the seed is not covered before drying (6, 8).

(3) Sown without treatment.

The results obtained in the rod-row experiments were not sufficiently promising, when compared with methods in common use, to warrant a continuance of these tests after the second year, but the results secured in the one-fortieth acre plats proved to be of considerable interest, due to the fact that seed treated with formaldehyde produced plants as free from loose smut as did seed from the same source treated with hot water. Humphrey and Potter (6) in 1918 mentioned the fact that

[1] The writers are indebted to Dr. George M. Reed, formerly Pathologist in Charge of Cereal Smut Investigations, Office of Cereal Investigations, who outlined these studies and supervised the work in its earlier stages.

loose smut of barley is more or less controlled by the use of the formaldehyde treatment. In the fall of 1920 and 1921 five varieties were included in these experiments, as there seemed to be some varietal difference in the behavior toward these treatments. In the fall of 1920, however, hot water was used only on Tennessee Winter, the idea being to concentrate on the formaldehyde treatment. The sowings were made each year during the first week in October so as to insure the greatest possible uniformity as to time of sowing. All of the seed used in these experiments was grown on Arlington Farm, Rosslyn, Virginia, the season previous to sowing. The same methods of harvesting and thrashing were used in each case and the seed was stored in bags in the same shed until time for sowing. Table 1 shows the results of these experiments with the average yields in bushels per acre obtained in each case.

The averages given in table 1 show that formaldehyde was just as effective in controlling loose smut of barley as was the modified hot-water teatment, while it was less effective in most cases in controlling the covered smut, for which it has been recommended. As is further shown in this table, little was gained in the way of yields by the use of either treatment. Some of the averages show gains while others show losses, and on the whole the differences are about balanced.

The results in table 1 show very clearly that there is a varietal difference in the reaction of the barleys to these seed treatments, especially in so far as yields are concerned. This conclusion is considered justifiable in view of the fact that all the seed was grown on the same farm and handled in the same way previous to the treatment. In every case Tennessee Winter yielded better where the seed was treated, while the yields of Wisconsin Winter and Cusado were decreased without exception. Texas Winter was included in the experiment only one year and gave increased yields from both treatments. The yields of Greece and Han River were increased in some cases and decreased in others. Evidently the nature of the seed of the different varieties renders them more or less subject to injury by these treatments. These data lead us to conclude that different modifications of these treatments will be necessary for different varieties of barley, if seed injury is to be avoided. On the other hand, there seems to be little probability of obtaining satisfactory smut control by the use of less severe applications, as covered smut is not controlled satisfactorily by the methods used. These treatments appear to be satisfactory for Tennessee Winter, and, perhaps, for Texas Winter, but they would not be considered applicable to the other varieties employed in these tests.

TABLE 1—*Three years' data showing the comparative efficiency of the formaldehyde and modified hot-water seed treatment in the control of the loose and covered smuts of barley.*

Variety	C. I. No.	Year of Crop	Results from treatment: Not treated — Per cent smut: Loose	Not treated — Per cent smut: Covered	Not treated — Yield bu. per acre	Formaldehyde — Percent smut: Loose	Formaldehyde — Percent smut: Covered	Formaldehyde — Yield bu. per Acre	Hot Water — Per cent smut: Loose	Hot Water — Per cent smut: Covered	Hot Water — Yield bu. per Acre	Gain (+) or loss (—) in bu. per acre by treatment: Formaldehyde	Gain (+) or loss (—) in bu. per acre by treatment: Hot water
Tennessee Winter	257	1920	8.3	12.1	20.6	trace	trace	21.4	trace	trace	24.4	+0.8	+ 3.8
" "	"	1921	11.7	21.9	20.9	0.3	3.4	26.7	0.0	trace	32.4	+5.8	+11.5
" "	"	1922	1.1	3.3	47.6	0.1	2.5	52.5	0.2	1.54	48.9	+4.9	+ 1.3
Texas Winter	554	1920	18.0	33.0	13.7	0.0	trace	17.9	trace	trace	17.7	+4.2	+ 4.0
Han River	2163	1920	15.6	24.0	22.7	trace	trace	23.3	0.0	11.6	21.8	+0.6	— 0.9
"	"	1921	9.6	32.0	22.9	0.15	26.7	30.4	—	—	—	+7.5	—
"	"	1922	0.6	6.8	46.9	0.14	5.9	43.4	0.1	1.4	47.8	—3.5	+ 0.9
Wisconsin Winter	2159	1921	10.9	8.3	27.6	0.0	2.4	26.4	—	—	—	—1.2	—
" "	"	1922	0.7	2.1	51.7	0.1	1.6	50.7	0.05	0.9	44.5	—1.0	— 7.2
Cusado	895	1921	14.6	28.7	22.1	0.0	13.8	20.5	—	—	—	—1.6	—
"	"	1922	3.7	7.5	51.5	trace	10.4	45.0	0.12	4.3	37.9	—6.5	—13.6
Greece	221	1921	6.3	18.8	21.8	0.0	7.3	26.6	—	—	—	+4.8	—
"	"	1922	0.6	2.8	61.7	0.2	1.4	56.5	0.3	2.7	48.9	—5.2	—12.8
Average for 5 varieties, Texas Winter not included	Comparing formaldehyde and untreated for 2 years (1921–1922)		6.0	13.2	37.5	0.1	7.5	37.9				+0.4	
	Comparing formaldehyde, hot water, and untreated for 1 year (1922)		1.3	4.5	51.9	0.1	4.4	49.6	0.15	2.16	45.6	—2.3	— 6.3
Averages for 2 varieties, Tennessee Winter and Han River	Comparing formaldehyde, and untreated for 3 years (1920–1922)		7.8	16.7	30.3	0.1	6.4	32.9				+2.6	
	Comparing formaldehyde, hot water and untreated for 2 years (1920 and 1922)		6.4	11.6	34.5	0.06	2.1	35.1	0.08	3.6	35.7	+0.6	+ 1.2
Averages for Tennessee Winter for 3 years													

Chlorophol and Copper Carbonate

In the fall of 1921, two other disinfectants, chlorophol, an organic mercury compound, and copper carbonate, were included in the agents used. Chlorophol is closely related to the mercuric compounds, Uspulun, which has been used in Germany since 1914 (11) or earlier, Germisan, of more recent discovery (1), and others of somewhat less value. These compounds have met with success in Germany where they are replacing the formaldehyde and copper sulphate methods for the control of grain smuts and certain other diseases. According to the several German publications on the subject, these mercury compounds cause no seed injury, but produce a stimulative effect. Copper carbonate was first used in Australia by Darnell-Smith (3), who obtained good results in the control of bunt of wheat. Satisfactory results have been obtained in the control of bunt of wheat in this country by Mackie and Briggs (10) and Heald and Smith (5). Only two varieties, Han River and Tennessee Winter, were treated with these compounds. Heavily smutted seed was used for these experiments, as also for the hot-water and formaldehyde treatments. All the seed used in the fall of 1921 was smutted artificially with covered smut, in addition to having been taken from seed lots showing heavy natural infestation.

Copper carbonate (C.P. basic) dust was shaken with the grain in a closed jar until there was a thin film of the dust over the surface of each kernel. Enough carbonate was added so that a small residue remained in the container, thus insuring a thorough application.

Chlorophol was used as a solution. The grain was soaked one hour in a 0.3 per cent solution and spread to dry before sowing. This strength was found to be effective in the control of oat smuts in preliminary experiments.

The results with these new treatments are so striking it seemed well to include them, even though they represent only one year of experiment. The results with copper carbonate indicate that this dust, though not injurious to the seed, will not satisfactorily control barley smuts under these conditions. The results with chlorophol, on the other hand, confirm the results obtained in Germany by the use of closely related organic mercury compounds, in that it causes no seed injury and, at the same time, gives an excellent smut control, averaging better than any other treatment, while the yields are very good. Tables 2 and 3 show the results of these experiments in comparison with those from the hot-water and formaldehyde treatments, and with untreated seed. Percentages of field germination given in these tables were obtained by

sowing 400 kernels from each treatment in the field on October 12, and counting the resulting plants on November 22. The percentage of field stands were estimated the following spring on the basis of the amount of space occupied by plants.

TABLE 2—*Results showing comparative value of seed treatments for the control of loose and covered smuts of Han River and Tennessee Winter barleys at Arlington Farm, Va., in 1922.*

Pl. no.	Variety	Treatment	Percentage of field germination	Percentage of field stand in spring	Percentage of smut		Yield bu. per acre
					Loose	Covered	
2	Han River	Untreated	61.5	98	1.0	11.1	55.8
3	(C.I. 2163)	Copper carbonate	72.2	95	2.2	6.4	54.6
4	"	Chlorophol	68.0	98	0.6	1.3	61.2
5	"	Formaldehyde	65.0	85	trace	5.16	47.7
6	"	Hot water	62.0	95	0.2	2.5	57.2
24	"	Untreated	61.5	75	0.15	2.7	38.0
25	"	Copper carbonate	72.2	92	0.85	2.77	35.7
26	"	Chlorophol	68.0	95	trace	0.2	47.5
27	"	Formaldehyde	65.0	75	0.28	6.7	39.2
28	"	Hot water	62.0	65	trace	0.35	38.4
7	TennesseeWinter	Hot water	77.2	95	0.6	2.5	48.1
8	(C.I. 257)	Untreated	78.7	100	1.6	4.7	48.5
9	"	Formaldehyde	75.2	95	0.2	2.4	50.4
10	"	Chlorophol	80.7	100	trace	0.1	58.7
11	"	Copper carbonate	82.2	98	0.9	1.9	53.3
12	"	Hot water	77.2	98	0.0	0.1	60.4
29	"	Untreated	78.7	98	0.5	1.85	46.7
30	"	Hot water	77.2	95	0.0	0.38	46.2
31	"	Formaldehyde	75.2	98	trace	2.5	54.6
32	"	Chlorophol	80.7	99	trace	0.2	56.4
33	"	Copper carbonate	82.2	98	3.67	5.26	50.4
34	"	Hot water	77.2	92	0.2	3.2	40.9

The results given in tables 2 and 3 show that in these experiments chlorophol was the most satisfactory treatment used. Field germinations were better with copper carbonate; but field stands in the spring, estimated on the basis of space occupied by plants, showed chlorophol to be superior in each case. This advantage is effectively shown in the yields. Even though the percentages of loose smut are very low, the results show that chlorophol was about as effective in controlling this smut as was formaldehyde or hot water and much more effective in the

TABLE 3—*Average results from 2 plats showing effects of seed treatments for the control of smuts in Han River and Tennessee Winter barleys at Arlington Farm, Va., in 1922*

Variety	Treatment	Average field germination	Average field stand—spring	Average percentage smut		Average yield in bu.
				Loose	Covered	
Han River (C.I. 2163)	Untreated	61.5	86.5	0.6	6.9	46.9
"	Copper carbonate	72.2	93.5	1.5	4.58	45.1
"	Chlorophol	68.0	96.5	0.3	0.75	54.3
"	Formaldehyde	65.0	80.0	0.14	5.9	43.4
"	Hot water	62.0	80.0	0.1	1.4	47.8
Tennessee Winter	Untreated	78.7	99.0	1.05	3.27	47.6
"	Copper carbonate	82.2	98.0	2.28	3.58	51.8
"	Chlorophol	80.7	99.5	trace	0.15	57.6
"	Formaldehyde	75.2	96.5	0.1	2.45	52.5
"	Hot water[1]	77.2	95.0	0.2	1.54	48.9

[1] Average of 3 plats.

control of covered smut. The cause for the percentages of loose smut being higher in the copper carbonate plats than in plats from untreated seed is unexplained unless the increased stimulation caused the weak seeds, which might have been infected and otherwise would not have germinated, to germinate and produce smutty plants. The treatment may have influenced the development of the loose smut in some other way. The percentages are so low that the differences may be due to experimental error.

CONCLUSIONS

(1) Formaldehyde, which has been recommended for the control of covered smut of barley, controlled loose smut better than it controlled covered smut.

(2) Hot water controlled loose smut about as well as did formaldehyde and controlled covered smut slightly better.

(3) On an average, both the hot water and formaldehyde treatments caused seed injury and little or nothing was gained by using them.

(4) There is a varietal difference in the behavior of barleys toward seed treatment. These treatments might be recommended for the control of smuts in Tennessee Winter, while they could not be recommended for such varieties as Greece and Wisconsin Winter.

(5) The efficiency of these treatments may vary under different local conditions. Furthermore, other varieties might behave differently toward them.

(6) Where the percentages of smut are not high, the results would not justify the use of the modified hot-water and formaldehyde treatments employed in these experiments.

(7) Of the two treatments, formaldehyde is much more easily applied, and, according to these results, is as efficient as hot water.

(8) In experiments of a single year, copper carbonate dust failed to control the smuts of barley, and apparently caused an increase in the percentages of loose smut. However, it had a favorable effect on seed germination.

(9) Chlorophol reduced the amount of loose smut, controlled covered smut effectively and caused an increase in field germination, field stands and yields of Han River and Tennessee Winter barleys in a single year of experiment.

OFFICE OF CEREAL INVESTIGATIONS,
U. S. DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

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AN IMPROVED FORMALDEHYDE TANK FOR THE ONION DRILL

P. J. Anderson and A. V. Osmun

With Three Figures in the Text

For controlling onion smut the only successful method which has been discovered is the application of formaldehyde to the seed and soil in the furrow at planting time. Selby[1] in 1902, was the first to apply this by means of a tank attached to the seeder. His apparatus consisted of an old maple syrup can with a tin outlet tube and "a suitable shut-off arrangement" which was suggested but not described. Stone[2], in 1909, described a more improved copper or galvanized iron tank which was attached in front of the seed box and partly over the wheel of the Planet Junior seeder. The outlet pipe was a quarter inch block tin flexible pipe in the course of which was inserted a globe valve for regulating the flow of formaldehyde solution. In 1914, Stone[3] described two other kinds of tanks, one which surrounds the seed box like a horseshoe and the other a somewhat cubical tank adjusted between the handles just back of the seed box. Each of these had a capacity of two gallons while his first tank held only one gallon. In the later models "an improvement over the earlier apparatus consisted in an iron rod attached to the valve and leading to the handles of the sower by means of which the operator could adjust the flow at will." Larger tanks which are attached to two-row drills and to eight-row horse drills were figured by Fernald and Osmun[4] in 1916. Various other modifications in the shape, position and capacity of the tanks have been made by plumbers and practical growers in the Connecticut Valley and are in use here but

[1] Selby, A. D. The prevention of onion smut. Ohio Agric. Exp. Sta. Bull. **131**: 50. 1902.

[2] Stone, G. E. The control of onion smut. Massachusetts Agric. Exp. Sta. Circ. 21. *2 p., 2 fig.* 1909.

[3] Stone, G. E. The control of onion smut. Massachusetts Agric. Exp. Sta. Circ. 41. *4 p., 4 fig.* 1914.

[4] Fernald, H. T. and A. V. Osmun. The control of onion diseases and thrips. Massachusetts Agric. Coll. Extens. Circ. 5. *4 p., 5 fig.* 1916.

in principle they are all the same. Similar tanks have been used by pathologists in Wisconsin,[1] New York, Oregon[2] and other states.

Renewed investigation on the control of smut was begun by the Department of Botany of the Massachusetts Agricultural Experiment Station in 1918. It was found at the very outset that no onion grower in the Connecticut Valley could be induced to use the extreme dilutions commonly recommended by experiment stations and push across the field the weight of water which such dilutions required, viz., about 200 gallons to the acre. Disregarding the experiment station recommendations, they were using more concentrated solutions and applying a smaller quantity per unit of row. The results were sometimes successful in controlling smut, sometimes worthless, at other times disastrous because they killed the seed with too great a concentration. Early in the investigation it became apparent that so much water was not necessary during ordinary seasons on the onion fields of the Connecticut Valley. The investigation finally resolved itself into an attempt to answer this question: What is the maximum concentration of formaldehyde and the minimum quantity of the same solution which will give profitable control of smut? Incidentally it should be mentioned that the onion grower does not object to a certain amount of injury to the seed since he can counterbalance this loss by setting the drill for a little more seed. A few extra pounds of seed is less expensive than the extra labor required to apply a safe dilute solution in larger quantities. The plan of the work was to try out in the smutted fields different concentrations of the formaldehyde and different quantities per unit of row and then keep accurate data on the amount of injury to the seed and on the control of smut. By continuing these tests through a series of years it was hoped that the data collected would answer the question stated above.

In order that the data obtained might be reliable, a machine was needed which would distribute evenly and with a fairly high degree of accuracy any desired quantity of solution on a stated length of row. For this purpose the regulating apparatus on all of the machines which are mentioned above was found to be worthless. None of them had a valve which could be set so that the operator would know when he started across the field how much solution would be applied per hundred feet. Actual tests of the different types of tanks showed considerable variation in the flow depending on how full the tank was. A 14-quart tank de-

[1] Walker, J. C. Onion diseases and their control. United States Dept. Agric. Farmers' Bull. 1060. *23 p., 12 fig.* 1919.

[2] Barss, H. P. Onion smut control. Oregon Agric. Exp. Sta. Crop Pest and Hortic. Rept. **3** (1915–20): 187. 1921.

scribed below required more than twice as long to deliver the last quart as it did the first. The one-gallon copper tank first constructed by Stone—which is still in the possession of the Station—was tested and showed a difference in time of 15% between the first and last pint. None of the tanks previously described have any method of correcting this error. None of them have any provision for eliminating the error due to variation in the speed of the operator. In short, there were so many sources of error and variation in all of the machines described up to the present that they were found to be utterly unsuitable for accurate

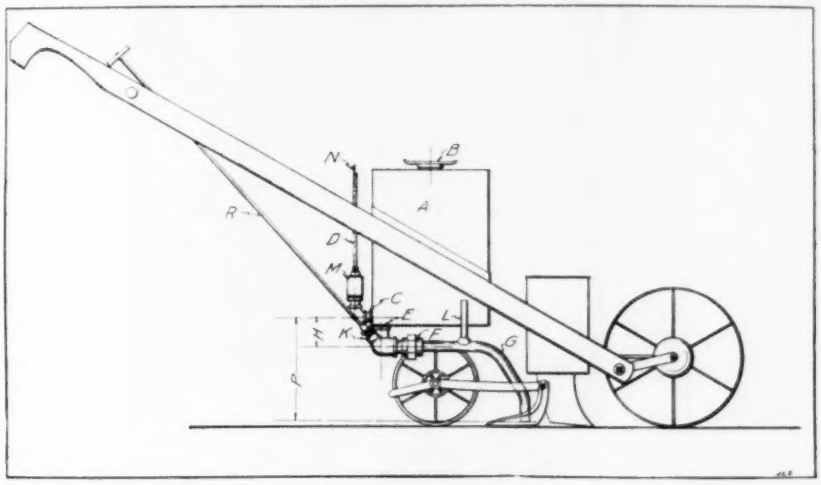

FIG. 1. Diagram of the tank, attached to Planet Junior seeder.

research studies and a new tank and method of regulation had to be devised.

Attempts were first made to calibrate the valve in the outlet pipe and, by means of a semicircular dial (on the cross bar of the handles of the planter) with numbered notches in the edge, to set the opening in the valve to permit the flow at any desired speed. Knowing the amount of solution which he wished to apply to a unit of row, it was first necessary for the operator to measure the speed at which he walked and then set the control lever at the proper notch on the dial. This arrangement was not quite satisfactory because it was necessary that the valve be completely closed in ½ revolution of the spindle and no valve could be found which would do this with even approximately equal increments. There was also sufficient "play" or wear in the parts of the valve or the

control lever to introduce variations in the flow even when the lever was set at the same notch on the dial at successive times. A gate valve and other types of valves were tried but all were found to be more or less unsatisfactory. Finally, the valve was abandoned as a means of regulating the flow and was used in our improved tank only for turning the stream on or off. The final improved form of the apparatus, which has

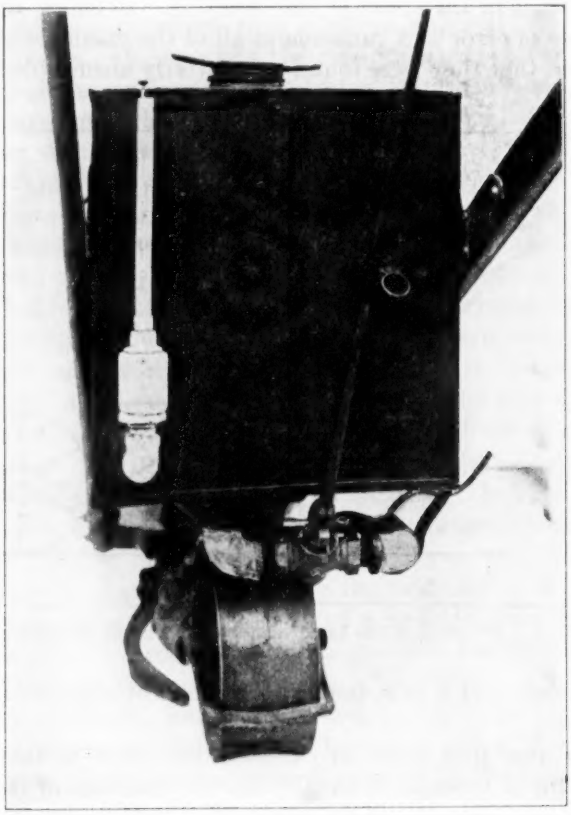

FIG. 2. Rear view of tank showing stand-pipe and arrangement of outlet pipe.

given satisfactory results in our field experiments, is described below and illustrated in the diagrammatic text figure 1.[1]

The tank itself (A) is a 14-quart cubical galvanized iron box attached between the handles of the drill just back of the seed box. The bottom

[1] This apparatus was completed in cooperation with the Department of Rural Engineering and credit for the working out of the mechanical details should be given to Professors C. I. Gunness and J. L. Strahan of that department.

of the tank is not flat but has a slight slope to a lowest point at the rear from which the solution is conducted through a ½-inch pipe (E) to the stopcock (K) and to the union (F). From there it is led through a ⅜ inch flexible block tin tube (G) and distributed on the seed and soil just back of the seed spout and in front of the coverers. The valve (K) is operated by a ¼ inch iron rod (R) from the rear end of the handles. It has nothing to do with the regulation of the flow but merely starts or stops the stream at the ends of the row or wherever desired. So much of the apparatus is not essentially different from that used by the previous investigators mentioned above. The modifications now to be described, however, have, so far as the writers know, never been used by other investigators.

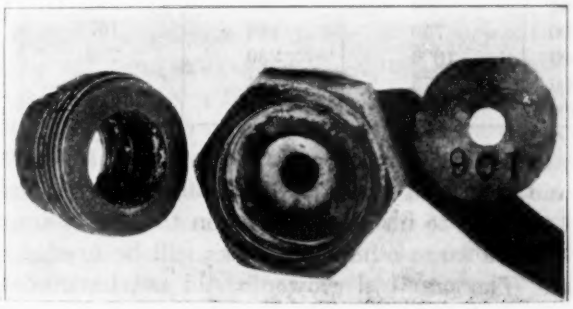

FIG. 3. Union in the outlet pipe taken apart to show position of disk and washers. Also a stamped disk at the left.

The rate of flow from the tank is regulated by a series of brass disks with central apertures of graded sizes. The disk is held in place between rubber washers in the union (F) of the outlet pipe (Fig. 3). Any number of these simple brass disks may be quickly cut out with tin shears from a sheet of brass. A hole is drilled through the center of each disk and this is enlarged with a rat-tail file to the proper size for the delivery of a gallon of solution in the previously calculated number of seconds which the operator wishes to use. The number of seconds required to deliver a gallon of solution is then stamped on the disk (Fig. 3). The size of the aperture needed depends on the formula of application which the operator wishes to use and the rate at which he walks. The number of disks which the experimenter or grower needs depends on the number of formulas he wishes to use and the number of men, of different speeds of walking, who expect to push his drill. Thus in our own experimental work seven different formulas of application were being tested and the drill was pushed at different times by three

operators, the first one walking 4 ft. per second, the second one 4½ ft. per second and the third one 5 ft. per second. Thus before the experiments were completed we had 21 disks. The operator could quickly find the proper disk by reference to a table attached to the side of the tank (Table 1):

TABLE 1: *Indicating the disks of the onion drill to be used according to the speed of workman and formula desired.*

Formula	One gallon of the solution on	4 ft. per sec.	4½ ft. per sec.	5 ft. per sec.
1– 50–3000[1]	480 ft.	120	106	96
1– 50–4000	640	160	142	128
1– 50–5000	800	200	178	160
1– 32–3000	750	188	167	150
1– 32–4000	1000	250	222	200
1– 64–3000	375	94	83	75
1–128–3000	187.5	47	42	37.5

To illustrate: if the operator found that he walked at the rate of 4½ ft. per second and he wished to use the 1–64–3000 formula, a glance at the table would tell him to insert in the union the disk stamped with the figure 83. Such a large number of disks will be needed only by the experimenter. The practical grower would not have occasion to use more than two or three and could make them as desired. This method of regulation was found to be very satisfactory and has the advantages of (1) permanent accuracy; no variation with wear or play; (2) cheapness and ease of construction within the reach of any grower; (3) simplicity; no complicated mechanism to be frequently out of repair, and (4) great elasticity, since a disk may be quickly made to suit any desired rate of flow.

The next modification was made for the purpose of correcting the variation in flow due to difference in head of the liquid as the quantity in the tank diminishes. All of the tanks which the writers have seen described have loose-fitting lids in the top through which the solution is poured to fill the tank. As the solution flows out through the outlet pipe the space which it leaves in the tank is immediately filled with air which comes in around the lid. Such an arrangement makes the rate of flow entirely dependent on the height of the water in the tank and as a result, the flow is much more rapid when the tank is full than when it is nearly empty. In order to determine the extent of such variation, the

[1] This formula means that 1 pint of commercial formaldehyde was diluted in 50 pints of water and applied to 3000 feet of onion row.

14-quart tank just described was filled and the water permitted to run out with the lid loose or removed entirely. The time required for delivering each of the successive quarts was determined with a stop watch and the average of 3 tests is indicated in table 2:

TABLE 2: *Rate of flow of each successive quart of liquid from 14-qt. tank (open).*

Quart	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Seconds	17.7	18.8	19.2	20.0	20.5	21.6	22.8	24.3	25.2	26.9	29.3	32.3	34.6	39.4

Thus the operator who started with a full tank would be putting on the first part of the treated row double the amount which he puts on the last part. The resulting control or injury would naturally show a similar variation. Data derived from the use of such a tank cannot be accurate. The variation in even the small tank described by Stone has been noted above. In order to make our control data reliable it was absolutely essential that this variation be eliminated. After considerable experimentation this was finally very successfully accomplished by modifying the tank thus: Instead of a loose-fitting lid, a screw cap (B), of 2-inch diameter (such as is commonly used on an automobile radiator) is used for closing the opening in the top. When screwed down with the shoulder against a rubber washer, this makes the top air-tight. A stand-pipe (D) parallel with and as high as the side of the tank is connected with the air vent (C) by means of an elbow. In this way, atmospheric pressure is maintained at the level of the vent (C) and consequently a uniform flow of solution is obtained irrespective of the height of water in the tank. The effective head producing the flow is always equal to (H). In order to prove that the flow is uniform, the outflow of each successive quart was timed just as described above but with the air-tight cap screwed down, and (with the no. 150 disk in the union) every quart from the first to the 14th flowed out in just 37½ seconds.

Two other modifications of minor importance have been added. In the enlarged base of the stand-pipe there is a float (M), which consists of a light hollow brass cylinder which has a "play" up and down of about 1 inch. Attached to the top of this float is a slender brass wire stem (N) passing up through the narrow part of the stand-pipe and projecting an inch above the top of it when the float is up but just even with the top when the float is down. When the stream is running from the tank and everything is in order, the float is down and the stem does not appear above the top. If, however, there is any leak in the top of the

tank or the operator has forgotten to screw down the cap, i. e. if the tank for any reason is not air-tight, the water rises in the standpipe to the level in the tank, the float remains up and the projecting stem warns the operator that something is wrong. The float is thus a safety device and not an absolutely essential part.

The second minor modification is a very small pipe (L) about 2 inches long inserted on the upper side of the outlet pipe. This was added when it was discovered that for each of certain intermediate disks there were two distinct rates of flow. If the pipe below the union became immediately filled with water when the stream was turned on, it continued to come out in a steady stream and we had the faster rate of flow. Under these conditions the effective head would be (P) in the diagram. But at other times, even with the same disk, air gained access to this pipe and the water dribbled out. Then we had the slow rate of flow due to the head (H). Either flow remained constant but one never knew when he opened the valve which speed he would have. This difference in flow was eliminated when air was admitted to the outlet pipe through the small opening and pipe just mentioned.

With this improved tank just described all chances of error due to variation are eliminated except one. Variation in the rate of application might arise from variation in the speed at which the workman pushes the drill; e. g., he might walk more slowly when he was tired or in softer land, etc. Numerous tests of the speed of different workmen at various times have convinced the writers, however, that a man's speed is remarkably constant and the error from this source is small. Nevertheless, it would be a distinct improvement if even this small error could be eliminated and the practical grower would be saved the trouble of measuring his speed and calculating the disk which he should use. This could be done if the apparatus were so constructed that the amount of solution delivered was proportionate to the distance travelled (i. e., to the number of revolutions of the drill wheel) and not dependent on the length of time during which the valve is open. Then the rate of application would be entirely independent of the speed at which the drill was pushed. Such a regulating apparatus, geared to the drill wheel, is mechanically possible and its construction has been planned at various times by the writers. The construction has been abandoned for various reasons but principally because it would be too complicated and expensive and therefore less suitable for the average onion grower. For all practical purposes, and even for a fairly high degree of accuracy for experimental work, the apparatus described above is quite satisfactory.

MASS. AGR. EXP. STATION

THE DUSTING OF WHEAT AND OATS FOR SMUT

F. D. Heald, G. L. Zundel and L. W. Boyle

With One Figure in the Text

INTRODUCTION

The control of bunt or stinking smut (*Tilletia tritici*) is the important problem in the wheat-growing section of eastern Washington. The treatment of seed wheat with bluestone or copper sulphate has predominated in the Palouse region, while in the wheat-growing regions of central Washington formaldehyde has been the fungicide usually employed.

There are, however, objections to the use of either copper sulphate solution or to formaldehyde in that both fungicides impair the germinating power (8, p. 17 and 13, p. 25–30) of the wheat so treated. When formaldehyde was first introduced, about 1897, it was thought that it would not injure the germinating quality of the treated wheat. This was soon proven to be an erroneous assumption.

It has been known for a long time that much of the injury from treating wheat in a solution of copper sulphate could be overcome by an after bath of milk of lime. Recently (14) it has been shown that the milk of lime is also effective in counteracting the ill effects of formaldehyde.

HISTORICAL

From work done in 1915 and 1916, Darnell-Smith (2) in 1917 reported excellent control of bunt by the use of copper carbonate dust. In addition to excellent control of bunt he showed that there was no injury to the seed. In 1919, Darnell-Smith and Ross (4) reported again on the use of copper carbonate to control bunt. In the latter part of 1919 Perkins (12) criticized the work of Darnell-Smith and Ross and rather questioned the efficacy of copper carbonate as a fungicide. In 1921 Darnell-Smith (3) answered the objections of Perkins to the use of copper carbonate. The work of the Australian investigators attracted the attention of American investigators and in 1920 and 1921, Mackie and Briggs (10, 11) of California published data confirming the work done by Darnell-Smith and Ross. In 1922, Lambert and Bailey (9) again confirmed the Australian investigations and further reported that oat smuts could be controlled by applying copper carbonate dust

to the seed. Again in 1922, Heald and Smith (6, 7) in Washington and Coons (1) in Michigan report good control of bunt by the use of copper carbonate, while the former authors have designed a special dusting machine which has been used with good results.

FIELD DEMONSTRATIONAL WORK

Bunt Control.—In the spring of 1921, field demonstrations using copper carbonate dust for bunt control were carried out in Franklin county in co-operation with the county agent. The results showed the superiority of copper carbonate over formaldehyde.

In the fall of 1921 in cooperation with the county agents the demonstrational work was extended to nine of the principal wheat-growing counties of the state, viz. Adams, Benton, Columbia, Franklin, Kittitas, Pend d'Oreille, Stevens, Walla Walla and Whitman. Over ten thousand acres of wheat were seeded in which the seed had been treated with copper carbonate, using two ounces of the powder for each bushel of wheat. This seed was planted in plots of varying size to compare it with the farmer's own treatment in which bluestone or formaldehyde was used.

It was observed that seed wheat treated with copper carbonate germinated from one to five days sooner, and the plants were more vigorous. There was very little seed injury to the copper carbonate treated seed. In a number of cases where seed was treated with formaldehyde or bluestone, there was severe winter killing, while seed planted in the same field and treated with copper carbonate overwintered uninjured.

Just before harvest (1922) each field demonstration was visited and the amount of smut was determined in the copper carbonate plots and in the parts of the field in which bluestone or formaldehyde was the fungicide used. Ten counts of 100 heads of wheat each were made for each treatment in order to determine the percentage of smut.

The appended table (Table 1) gives the average percentage of smut for the different treatments in the various counties. In case no smut was found in the field, it was not included in the average. Eight trial fields in Adams County, four in Franklin, one in Columbia and two in Kittitas were free from smut.

Oat Smut Control.—Lambert and Bailey (9) first reported the use of copper carbonate to control the smuts of oats. In the spring of 1922, five field demonstrations were started in Skagit County, in cooperation with the county agent to test the comparative value of formaldehyde and copper carbonate. Each bushel of oats was treated with two ounces of copper carbonate. The standard formaldehyde treatment was used.

Just before harvest, the county agent, C. H. Bergstrom, determined the percentage of smut by making ten counts of 100 panicles each for each treatment. The average percentage of smut in the five demonstrations was as follows:

Untreated 8.9; formaldehyde 0.20; formaldehyde + lime after bath 1.10; copper carbonate 1.17.

TABLE 1—*Summary of farm demonstrations showing comparative effectiveness of bluestone, formaldehyde and copper carbonate in the control of bunt 1922*

County	No. of co-operators	Average percentage of smut							
		Bluestone	Copper carbonate	Bluestone Lime	Copper carbonate	Formaldehyde	Copper carbonate	Formaldehyde +Lime	Copper carbonate
Adams	3	10.4	.8						
Franklin	3					4.2	.4		
Benton	2	.8	.45						
Columbia	8	12.9	8.5	9.7	8.1	18.1	11.	19.6	6.6
Pend Oreille	1					35.	3.7		
Stevens	5					4.9	2.		
Kittitas	1	2.2	.2	0.3	.2	1.6	.2	0.4	.2
Whitman	13	16.5	10.8	14.6	10.8	12.9	6.7		
Walla Walla	12	9.4	9.1			16.0	9.		
Wash. State Avg.		10.9	7.2	11.0	8.5	9.1	3.1	10.2	3.4

EXPERIMENTAL WORK

A series of experiments relative to the use of copper carbonate dust treatment for control of cereal smuts have been carried out during the past two seasons. These experiments were outlined to determine the following points: (1) The comparative protection of various fungicides for stinking smut of wheat from seed-borne spores; (2) the effect of certain seed treatments on prevention of bunt from soil contamination (summer fallow); (3) to what extent, if any, copper carbonate dust treatment for smut injures the seed and if extended storage before planting makes a difference; (4) to what extent copper carbonate dust is effective in the control of oat smut (*Ustilago levis* (K. & S.) Mag.).

THE COMPARATIVE TESTS OF VARIOUS FUNGICIDES FOR BUNT CONTROL IN SPRING WHEAT

In making these comparative tests, three varieties of seed were used, namely, Marquis, a resistant "vulgare" type, Bluestem, a susceptible

"vulgare" type, and Jenkins Club, a susceptible "compactum" type. Before treatment all the seed was artificially smutted by shaking or churning it in a flask with one of three different amounts of smut powder. (Smut powder is prepared by grinding smutted heads through a food chopper and sifting through a fine sieve.) The amounts of smut powder used and approximate number of smut spores carried per grain of wheat were as follows:

Light	smutting—0.1 gr.	smut	powder	per	100	gr.	ms.	seed	=	9,000	spores	per	grain
Medium	" —0.4 "	"	"	"	"	"	"	"	"	36,000	"	"	"
Heavy	" —1.0 "	"	"	"	"	"	"	"	"	90,000	"	"	"

Heavily smutted seed appeared black and carried a much greater number of spores than seed used in ordinary farm practice. The dust treatments were applied in the same way, by shaking the smutted seed in a large flask with the powder. The seed was hand planted in duplicate rod rows, care being taken after planting a heavily smutted sample, to wash the hands before planting a sample of lighter smutting. At harvest counts were made to determine percentage of clean plants, percentage of partially smutted plants, percentage of totally smutted plants and percentage of smutted heads.

The first series of plantings were made of seed treated with varying amounts (½ to 3 oz. per bu.) of copper carbonate dust to determine if possible the minimum amount which could be used to obtain a practical maximum protection. Besides the treatments with pure copper carbonate, hydrated lime was used as a diluent with equal amounts of copper carbonate.

The maximum percentage of smutted heads produced in any planting of mediocre smutting, even with reduced amounts of copper carbonate, was 0.9, the average being 0.21 per cent as compared with 24.26 per cent smutted heads in control plantings of untreated medium smutted seed. The average percentage of smutted heads produced by heavily smutted treated seed was 0.97 as compared with 40.5 per cent produced by controls of heavily smutted untreated seed. The average for all copper carbonate treatments was 0.41 per cent. Copper carbonate treatments of spring wheat, using two ounces per bushel, carried out in 1921 gave complete protection from bunt, as reported by Heald and Smith (6), but in our 1922 tests it required 3 oz. per bushel to give a smut-free crop.

The second series of plantings was made with seed smutted in the same way but treated with various amounts of finely powdered anhydrous copper sulphate mixed with equal amounts of either finely powdered calcium carbonate or hydrated lime. Such mixtures should produce copper carbonate in contact with soil moisture and were treated with the

TABLE 2—*Results in control of stinking smut, using various quantities of copper carbonate dust. Spring seeding 1922.*

Treatment	Variety	Average percentage of smutted heads for three degrees of smutting	Degree of smutting	Average percentage of smutted heads for three varieties
Copper carbonate ½ oz. per bushel	Marquis	0	Light	.29
	Bluestem	0	Medium	0
	Jenkins Club	1.65	Heavy	1.03
Copper carbonate ½ oz. plus hydrated lime ½ oz. = 1 oz. per bushel	Marquis	0	Light	0
	Bluestem	.42	Medium	.27
	Jenkins Club	2.01	Heavy	2.16
Copper carbonate 1 oz. plus hydrated lime 1 oz. = 2 oz. per bushel	Marquis	0	Light	.12
	Bluestem	1.90	Medium	.44
	Jenkins Club	.38	Heavy	1.72
Copper carbonate 1 oz. per bushel	Marquis	0	Light	0
	Bluestem	.26	Medium	.26
	Jenkins Club	0	Heavy	0
Copper carbonate 2 oz. per bushel	Marquis	0	Light	0
	Bluestem	.29	Medium	.3
	Jenkins Club	.6	Heavy	.59
Copper carbonate 3 oz. per bushel	Marquis	0	Light	0
	Bluestem	0	Medium	0
	Jenkins Club	0	Heavy	0

idea of substituting the cheaper mixture for the more expensive copper carbonate. The plantings of seed treated with anhydrous copper sulphate mixed with hydrated lime gave an average of 1.65 per cent smutted heads as contrasted with an average of 23.3 per cent in all untreated controls. The anhydrous copper sulphate mixed with calcium carbonate averaged 0.77 per cent, which gives it a preference over the hydrated lime mixture. The average for all the anhydrous copper sulphate mixtures was 1.4 per cent smutted heads as contrasted with 0.41 per cent smutted heads for all the copper carbonate tests. No complete protection was afforded except in the case of the highly resistant variety, Marquis.

TABLE 3—*Results in control of bunt, using various amounts of anhydrous copper sulphate.*[1] *Spring seeding 1922.*

Treatment	Variety	Average percentage of smutted heads for three degrees of smutting	Degree of smutting	Average percentage of smutted heads for three varieties
Anhydrous copper sulphate ½ oz. plus calcium carbonate ½ oz. = 1 oz. per bushel	Marquis	0	Light	.10
	Bluestem	1.74	Medium	1.8
	Jenkins Club	1.96	Heavy	1.8
Anhydrous copper sulphate 1 oz. plus calcium carbonate 1 oz. = 2 oz. per bushel	Marquis	0	Light	.12
	Bluestem	.34	Medium	.9
	Jenkins Club	.51	Heavy	.63
Anhydrous copper sulphate 2 oz. plus calcium carbonate 2 oz. = 4 oz. per bushel	Marquis	0	Light	.42
	Bluestem	1.56	Medium	.32
	Jenkins Club	.81	Heavy	1.61
Anhydrous copper sulphate ½ oz. plus hydrated lime ½ oz. = 1 oz. per bushel	Marquis	.37	Light	.90
	Bluestem	4.93	Medium	1.68
	Jenkins Club	.84	Heavy	3.55
Anhydrous copper sulphate 1 oz. plus hydrated lime 1 oz. = 2 oz. per bushel	Marquis	0	Light	0
	Bluestem	1.25	Medium	.275
	Jenkins Club	.87	Heavy	1.84
Anhydrous copper sulphate 2 oz. plus hydrated lime 2 oz. = 4 oz. per bushel	Marquis	0	Light	.29
	Bluestem	.54	Medium	.84
	Jenkins Club	1.14	Heavy	.54

The third series of plantings was made with seed smutted in the same way as the others, but treated with the Corona[2] compound of copper carbonate for comparison with pure copper carbonate (Table 4). The Corona compound contained 17 to 18 per cent metallic copper as compared with about 50 per cent in the pure copper carbonate. The

[1] See table 4 for controls.

[2] Furnished by the Corona Chemical Division of the Pittsburgh Plate Glass Company, Milwaukee, Wisconsin.

average percentage of smutted heads in plantings of comparative samples were as follows:

½	oz.	copper carbonate	per	bushel,	0.54	per	cent	smutted	heads
1	"	"	"	"	0.087	"	"	"	
2	"	"	"	"	0.29	"	"	"	
3	"	"	"	"	0.00	"	"	"	
2	"	Corona compound	"	"	0.077	"	"	"	
4	"	"	"	"	0.00	"	"	"	
No treatment No. 1					17.88	"	"	"	
No treatment No. 2					28.72	"	"	"	

This single test, however, indicates that Corona compound has a better protective action than pure copper carbonate carrying an equivalent of metallic copper. With this series were made plantings of seed treated with Seed-O-San, an organic mercury compound furnished by Standard Seed Tester Company, Chicago, Illinois. This is also in dust form and applied in the same way. It did not give as good protection as the copper dusts in plantings of heavily smutted seed, but was quite effective in the plantings of light and medium smutted seed. (See table 4.)

COMPARATIVE TESTS OF VARIOUS FUNGICIDES FOR BUNT CONTROL IN WINTER WHEAT

When planting wheat in the fall, the problem has been how to control reinfection of seed from wind blown smut spores in the soil. Previous experiments have shown nearly perfect control of smut by the use of bluestone, formaldehyde and copper carbonate treatments when this was not a factor. A series of comparative tests were made to determine the effectiveness of various fungicides in control of smut from soil contamination. Three varieties were used: Hybrid 128, a very susceptible "compactum" type; Turkey Red, a very resistant variety; and Red Russian, a rather susceptible variety. These were not artificially smutted as in experiments with spring wheat, but were planted in duplicate rod rows on summer fallow which had been artificially smutted. The smutting was done with a hand duster to insure as uniform distribution of the powdered smut as possible. The soil then contained far more smut than normal summer fallow.

Assuming no protective action from the formaldehyde treatments (average 25 per cent smutted heads) all of the copper treatments showed a reduction (15.12 per cent smutted heads) in resulting amount of smut. Copper carbonate dust treatment averaged 18 per cent smutted heads, which is in excess of the average amount in the several tests with blue stone. It is significant that the copper sulphate sprinkle, using 1 pound

TABLE 4—*Results in control of stinking smut, using Corona compound of copper carbonate, Seed-O-San, and controls of untreated smutted seed. Spring seeding 1922*

Treatment	Variety	Average percentage of heads of three degrees of smutting	Degree of smutting	Average percentage of smutted heads for three varieties
Corona compound of copper carbonate 2 oz. per bushel	Marquis	0	Light	0
	Bluestem	.08	Medium	0
	Jenkins Club	.15	Heavy	.23
Corona compound of copper carbonate 4 oz. per bushel	Marquis	0	Light	0
	Bluestem	0	Medium	0
	Jenkins Club	0	Heavy	0
Seed-O-San 2 oz. per bushel	Marquis	0	Light	.18
	Bluestem	1.48	Medium	.18
	Jenkins Club	.60	Heavy	1.72
Control No. 1 untreated smutted seed	Marquis	.43	Light	3.63
	Blustem	25.8	Medium	12.58
	Jenkins Club	27.63	Heavy	39.5
Control No. 2, untreated smutted seed	Marquis	.71	Light	6.52
	Bluestem	41.85	Medium	37.99
	Jenkins Club	43.58	Heavy	41.64

to 1 gallon of water at the rate of ½ gallon per bushel, gave the best protection, while sulphur showed but little protection.

A second series of plantings to determine the comparative value of various fungicides in control of smut from soil contamination was made in 1140 acre plots. Hybrid 128, Red Russian and Turkey Red were the varieties used in these plantings. Smut percentages were obtained by counting the total number of heads (1000–4000) in a drill row. It can be assumed that the smut (8.3 per cent) in the plantings of seed treated with formaldehyde 1 to 40 came from soil contamination and that the seed carried very little smut, since the average for the untreated seed was 8.64 per cent smutted heads (Fig. 1). All the copper treatment showed a reduction in the amount of smut over formaldehyde with the best protection afforded by the standard blue-stone treatment followed by the lime bath. The copper carbonate dust treatment gave a reduction of 2.78 per cent over formaldehyde as compared with 2.28 per cent reduction from anhydrous copper sulphate. The results obtained with the spring seedings suggest that 3 oz. of copper carbonate per bushel

would have given an equal or better protection than the bluestone treatments.

TABLE 5—*Comparative effect of seed treatments in preventing smut in winter wheat planted in artificially smutted summer fallow. Fall seeding 1921.*

Treatment	Hybrid 128 Percentage smutted heads	Turkey Red Percentage smutted heads	Red Russian Percentage smutted heads	Average percentage smutted heads
Sulphur, 200 lbs. per A.	43.2	0.0	20.9	21.3
Sulphur, 20 lbs. per bu.	50.3	0.1	28.5	26.2
Formaldehyde 1–40....	49.6	5.2	23.8	26.2
Copper carbonate 2 oz. per bu.....	36.2	3.9	13.9	18.0
Anhydrous copper sulphate 1 oz. calcium carbonate 1 oz.....	25.	6.2	24.3	18.5
Copper sulphate 1–5...	6.	4.3	27.5	12.6
Copper sulphate 1–5 plus lime bath.....	21.3	2.9	22.3	15.5
Formaldehyde 1–40....	34.4	4.4	32.3	23.7
Copper sulphate 1–1 sprinkle.....	15.9	1.5	15.7	11.03

THE EFFECT OF COPPER CARBONATE ON GERMINATION OF WHEAT

Besides being effective as a seed fungicide in control of stinking smut of wheat and oat smut, copper carbonate has no toxic effect upon treated seed (10, 11, 9, 6). This is of considerable advantage, since as stated before the commonly used formaldehyde and bluestone treatments injure the seed to a marked degree. Copper carbonate also has a stimulating effect, inducing more rapid germination and more vigorous growth.

Since there is often a congestion of work on the farm at the period when treating and sowing of seed is usually done, the question arises as to whether seed might be treated some months previous to seeding and

TABLE 6.—*Comparative effects of seed treatments in preventing stinking smut in winter wheat planted in ordinary summer fallow. Fall seeding 1921*[1]

Treatment	Hybrid 128	Turkey Red	Red Russian	Average
	Percentage smutted heads	Percentage smutted heads	Percentage smutted heads	percentage smutted heads for three varieties
Untreated	17.4	1.5	9.8	9.56
Copper carbonate 2 oz. per bushel	13.0	1.4	3.2	5.86
Anhydrous copper sulphate 1 oz. plus calcium carbonate 1 oz. =2 oz. per bushel	14.8	0.5	3.8	6.36
Copper sulphate 1–5	10.5	0.6	3.8	4.96
Copper sulphate 1–5 plus lime bath	7.1	0.7	3.7	3.83
Formaldehyde 1–40	18.6	0.6	5.7	8.3
Untreated	14.7	1.4	7.1	7.73

stored without injurious effect. To determine this point, four common varieties of wheat were each treated with the standard amount (2 oz. per bushel) of copper carbonate dust. Comparative germination tests were made of this seed and untreated seed of the same lots. Monthly tests were made by planting 200 seeds of each sample in flats in the greenhouse and counting the number of seedlings. The results (See table 7) show that after a period of nine months no injury resulted, while the treated grain showed an average increased germination over untreated seed.

The effectiveness of copper carbonate in control of oat smuts.—Oat smut (*Ustilago levis*) like stinking smut of wheat is seed-borne and controlled by the same formaldehyde treatment. Seed injury and other disadvantages of this treatment, being overcome by use of copper carbonate

[1] From an experiment in cooperation with Division of Farm Crops, Washington Agriculture Experiment Station.

dust in control of stinking smut of wheat, suggested possibilities of its effectiveness in control of oat smut.

In making this test, the same methods of smutting, treating and planting the seed, as described for wheat were used. Three varieties, Swedish Select and Abundance, both moderately susceptible, and

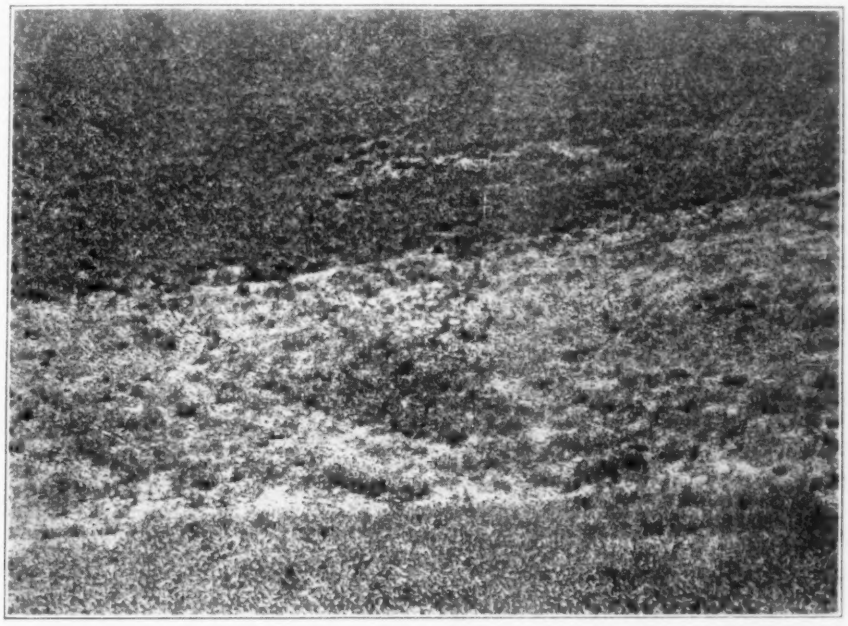

FIG. 1. Turkey Red wheat fields on Nunamaker Ranch, near McAdams, Franklin County, Washington. Fields seeded at rate of 70 pounds in November, 1921; photographed May 24, 1922. Light area from formaldehyde-treated seed; heavy stand from seed treated with copper carbonate. Photo by H. Simonds.

Chinese Hulless, very susceptible, were used, and the following three degrees of smutting were employed:

Light	smutting	=	0.1	gr.	of	smut	powder	per	100	grams of seed
Medium	smutting	=	0.4	"	"	"	"	"	100	" " "
Heavy	smutting	=	1.0	"	"	"	"	"	100	" " "

The copper carbonate was used in amounts equal to 2, 3 and 4 oz. per bushel of seed.

The results (Table 8) shows the copper carbonate dust far more effective with the hulless variety than with the common varieties. The average

TABLE 7—*Comparative germination percent of untreated and dusted seed of several varieties of wheat*

Date of Test (1922)	Jenkins Club		Hyrbid 128		Marquis		Jones Winter Fife	
	Untreated	Cu CO_3	Untreated	Cu CO_3	Untreated	Cu CO_3	Untreated	Cu CO_3
Feb. 7	85	88.5	87.5	92.5	89.5	94.5	95	90.5
Mar. 8	67.5	90	75	60	96	85	91	96
Apr. 15	81.5	——	80	——	84	——	92	——
May 8	76	95	79.5	89.5	77	96	84	96
June 24	77	84.5	80.5	81.5	82.5	91.5	87	92
July 7	73	84.5	83.5	91	85	91.5	91.5	94.5
Aug. 9	79.5	78	71	87.5	82	90	78.5	91
Sept. 7	84	83.5	84	85	84.5	85.5	87	92
Oct. 7	80	81.5	82.5	80	83.5	85	82	84.5

treated hulless plantings gave 0.33 per cent smutted panicles as compared with 3.53 per cent in the common varieties, while the untreated hulless plantings showed an average of 70.45 per cent smutted panicles as compared with similar controls of hulled varieties showing 23.45 per cent. The average for all treated samples was 2.47 per cent smutted panicles as compared with 39.12 per cent average for untreated samples. The use of 2 oz. copper carbonate per bushel gave practically as good control as larger amounts of the dust. Lambert and Bailey (9) reported tests in Minnesota giving perfect control of oat smut and no seed injury by use of copper carbonate, but our tests have not given such good protection. The protection afforded by the copper carbonate was not equal to that ordinarily obtained with the standa d formaldehyde treatments.

DISCUSSION AND SUMMARY

The experiments reported have given very promising results on bunt control from the use of a number of dust treatments, with copper carbonate dust leading in effectiveness. It has been generally conceded that the present methods of seed disinfection for bunt have numerous undesirable features. Some of the features which any other method should have in order to replace the old standard methods are as follows:

1. The elimination of the inconvenient and disagreeeable soaking or steeping methods.

2. The elimination of seed injury and retarded growth under conditions of average moisture.

TABLE 8—*Results of control of oat smut using copper carbonate dust treatment*

Treatment	Variety	Average Percentage of smutted panicles for three degrees of smutting	Degree of smutting	Average Percent- of smutted panicles for three varieties
Copper carbonate dust 2 oz. per bushel	Swedish Select	2.9	[2]Light	4.13
	Abundance	6.14	Medium	2.45
	[1]Chinese Hulless	0	Heavy	5.5
Copper carbonate dust 3 oz. per bushel	Swedish Select	2.87	[2]Light	2.8
	Abundance	3.55	Medium	2.79
	[1]Chinese Hulless	0	Heavy	1.73
Copper carbonate dust 4 oz. per bushel	Swedish Select	2.22	[2]Light	.73
	Abundance	3.55	Medium	2.12
	[1]Chinese Hulless	1.00	Heavy	3.90
Control smutted untreated	Swedish Select	28.12	[2]Light	16.88
	Abundance	18.79	Medium	34.52
	Chinese Hulless	70.45	Heavy	48.16

3. The elimination of danger from seeding in the dry, so as to make possible the seeding of grain in the "dust."

4. The possibility of treating seed days or even months before it is needed for seed, without extra expenditure of labor, thus making possible the utilization of spare time.

5. A better protection from reinfection of treated seed than is afforded by bluestone, especially from wind-borne spores that are generally present in our summer fallow fields.

6. The increase of yields over those obtained with the old methods.

According to the results of our experiments, copper carbonate dust comes nearer to embodying these desired features than any other fungicide. Under no conditions have we found any reduction in germination from the use of this fungicide, either immediately after treatment or after a period of nine months storage. On the contrary there has been an improved germination of treated seed over untreated, resulting under field conditions in better stands, a more rapid germination and a more vigorous growth. Our field records indicate that copper carbonate gives less loss from winter injury and increased yields, although reliable quantitative data on yields are not yet available. As far as

[1] Average for Chinese Hulless for medium and heavy degrees of smutting only.

[2] Average for light degree of smutting for Swedish Select and Abundance only.

seed injury is concerned, seeding in the dry is absolutely safe with copper carbonate, but we do not yet have data on the effectiveness of the fungicide under different conditions of soil moisture. Some of the results point to its greater effectiveness in dry soils.

Copper carbonate has been effective in preventing smut from seed-borne spores as shown by spring seedings, two ounces per bushel of seed giving a smut-free crop in our experiments of 1921 and three ounces per bushel affording perfect protection in 1922. This has been true with light, medium and heavy smutting in which the untreated seed gave the following results:

Degree of smutting	Average percentage of smutted heads from duplicates		
	Marquis	Bluestem	Jenkins Club
Light smutting	0.47	6.42	8.35
Medium smutting	0.42	36.33	36.05
Heavy smutting	0.83	58.4	62.48

In the prevention of smut from fall seedings on summer fallow, the results have not been quite so convincing. The field demonstrations in eight counties showed better control with copper carbonate than with either bluestone or formaldehyde, although there were a few specific cases in which bluestone gave less smut. In some local experiments, using three varieties in both smutted and normal summer fallow, the copper carbonate was not quite equal to bluestone but gave better protection than formaldehyde. It is felt that some of the adverse results obtained with copper carbonate were due to inferior brands, and this possibility is being checked by further experiments.

The comparative protection given by the dust fungicides tested when used for heavily smutted spring seedings at the rate of 2 oz. per bushel was as follows:

Fungicides	Percentage of smutted heads		
	Marquis	Bluestem	Jenkins Club
Copper carbonate, pure	0	0.89	0.9
Corona compound of copper carbonate	0	0.25	0.45
Anhydrous bluestone and calcium carbonate	0	0.74	1.15
Anhydrous bluestone and hydrated lime	0	3.75	1.79
Seed-O-San	0	3.9	1.27

Corona compound of copper carbonate, containing 17 to 18 per cent of metallic copper, gave practically as good protection as the pure copper carbonate, while the much cheaper mixture of anhydrous bluestone and calcium carbonate was not far behind in effectiveness. Our results indicate that less than two ounces of copper carbonate may give protection if in form to insure a perfect distribution over the seed. Our experiments on the comparative effectiveness of these dusts for fall seedings have not yet been completed.

In the treatment of oats for smut (*Ustilago levis*) formaldehyde gave better results than copper carbonate as the average of five farm demonstrations. In our local experiments with three varieties, copper carbonate gave perfect control in Chinese Hulless, but rather poor protection in Swedish Select and Abundance.

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THE GENUS POLYSTICTUS AND DECAY OF LIVING TREES

JAMES R. WEIR

Extensive field observations show that some of the common species of Polystictus are not entirely confined to the wood of dead trees. The most common species of the genus found in the United States and the actual cases in which they have been observed to attack the sapwood or heartwood of living trees are as follows:

1. *Polystictus abietinus* (Dicks) Fr.; on the dead wood of blazes, fire scars and frost cracks of *Abies grandis*,[1] *Tsuga heterophylla* and *Thuya plicata*, Idaho, Washington, and Montana. The sapwood is decayed and the adjacent heartwood discolored. The trees were of low vigor. Like conditions have been observed on *Abies balsamea* in northern Minnesota.

2. *Polystictus biformis* Kl., (*P. cervinus* (Schw.) Cke.) on dead wood of living brace roots of *Quercus rubra* and *Fagus atropunicea*, causing a decay of the sapwood and heartwood, extending into the trunk; Indiana and Ohio.

3. *Polystictus cinnabarinus* (Jacq.) Fr.; on the dead wood of a large open wound on living *Betula occidentalis*, the rot extending into the heartwood for several inches beyond the edge of the living sapwood; Idaho.

4. *Polystictus conchifer* (Schw.) Sacc.; common on the dead branches of various species of Ulmus killed by shade or other causes. The decay may extend within the living collar of the dead branch from one to three inches. The writer has never observed the fungus to form a heart rot in this position. The fungus is not parasitic and will not directly attack a living branch, although it often appears to do so. Inoculations on healthy branches of Ulmus at Great Falls, Va., August, 1921, resulted negatively. Common throughout the Middle West and Eastern United States. Rarely found on the wood of other trees.

5. *Polystictus floridanus* (Berk.) Fr. (resupinate form *Poria lindbladii* Berk.) on the dead wood of wounds in root crotches of living *Liquidambar styraciflua*, Alabama, and on fire scars on living roots of *Chamaecyparis thyoides*, North Carolina, the decay encroaching upon the more vital parts of the roots.

[1] Tree nomenclature according to Sudworth, G. B. Check list of the forest trees of the United States, their names and ranges. United States Dept. Agric., Div. Forest. Bull. 17. *144 p.* 1898.

6. *Polystictus hirsutus* (Wulf.) Fr.; causing a sapwood and heartwood rot of living cultivated plum, cherry, prune, peach and apple. Idaho, Washington, Oregon, Indiana. The fungus enters through knots of pruned branches, frost checks and scars made during cultivation. The decay which may be uniform in the heartwood is often serious and results in the trees being broken by the wind. Many small sporophores (4) may appear at the lenticels. The fungus has been observed in the heartwood of living *Alnus tenuifolia*, *Betula occidentalis*, *Acer rubrum*, *Quercus prinus*, *Q. coccinea* and *Castanea dentata:* Idaho, Indiana, Michigan, Tennessee.

7. *Polystictus lacteus* (Fr.) causes a sap and heart rot in living cultivated plum, cherry, peach, and apple. Occasionally the fungus is of considerable economic importance. Zeller (5) states that it causes the most common heart rot of sweet cherry in western Oregon. The fungus enters through pruning scars and other injuries, on street and park trees and occasionally in the forest, it attacks the wood of large wounds and causes a local decay of the heartwood. Acer, Platanus, Quercus and Ailanthus; Washington, Oregon, Idaho, Indiana, and Virginia.

8. *Polystictus pargamenus* Fr. This fungus when once established on the dead wood of wounds on living trees may continue to rot the heartwood indefinitely. This condition has been observed on *Quercus alba*, *Q. coccinea*, *Q. marilandica*, *Acer saccharum*, *Betula lutea*, *Fraxinus americana*, *Nyssa sylvatica* and *Populus tremuloides*. Indiana, Tennessee, Michigan, Virginia. Numerous minor cases on various hosts have been observed. Rhoads (1) has called attention to the action of this fungus in several trees.

9. *Polystictus pinsitus* (Fr.) Cke. on dead wood of blazes and open knots of living *Juniperus virginiana* and *Chamaecyparis thyoides* confined chiefly to the surrounding dead sapwood. Virginia and North Carolina.

10. *Polystictus versicolor* (L.) Fr., causes a heart and sapwood rot in living trees of various species. The fungus enters through the dead wood of exposed wounds and may, in some cases, become of economic importance. Von Schrenk (2) and Stevens (3) have fully described the damage caused by this fungus in Catalpa. Ordinarily the fungus is of little importance on living trees.

11. *Polysticus zonatus* Fr., a well defined species and especially abundant in the western United States, occasionally causes a heart rot in living trees of Populus and Salix. The fungus enters through the exposed wood or wounds. Notable cases are recorded in Idaho, Washington and in the Black Hills of South Dakota.

With the exception of the purple pored species, numbers 1, 5, and 8, all of which cause a characteristic rot with small, elongated pockets, the rots of the majority of the species mentioned are not especially differentiated. The character of the decay, however, may be influenced slightly by the species of tree structure and the physical nature of the wood. This may be observed when any of the above named species which normally grow on the wood of frondose trees attack the wood of conifers, an occasional occurrence, or in a change from porous to nonporous wood. The general color of the decays of all the species mentioned is usually white or yellowish or of a slight reddish cast in the case of *Polystictus cinnarbarinus*, due to the massing of hyphae near the sporophore.

In but few cases have the Polystictus rots been found to be of much importance on forest trees and may be disregarded in the management of original forest lands. Usually dependent upon the presence of a large amount of weathered dead wood to effect encroachment on the heartwood or the adjacent sapwood, the decay of most species makes slow progress in otherwise healthy trees. Trees whose vigor is reduced by extensive injuries involving a large part of the side of the trunk or the brace roots may suffer greater damage. As a rule, these fungi are not to be considered in the same class with the true destructive cull fungi of living timber trees. They are primarily the scavengers of the forest; decaying the slash of timber sale areas, and other debris, but may become important in the decay of useful material too long left in the woods or in hastening the decline of street and park trees.

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PHYTOPATHOLOGICAL NOTES

Poria papyracea (Schw.) Cke.—This rare and interesting species has been recently collected by the writer as an epiphyte on the thin, smooth chlorophyllaceous bark of *Chamaecyparis thyoides* in the Dismal Swamp of Virginia. The area of bark over which the fungus extended was browned and somewhat sunken below the general level, but the vital parts were not affected. The fungus has also been found on dead fallen twigs and branches of *Thuja occidentalis* by J. J. Neuman at Crandon, Wisconsin, and by Dr. A. H. W. Povah at Vermilion, Michigan. Good collections in the N. Y. Botanical Garden were made by Underwood on Vitis at Auburn, Alabama. The original specimen was collected by Schweinitz on dead bark of Vitis in Carolina. It was later collected by Peters (464) on Vitis in Alabama, and described by Berkeley and Curtis under the name of *Polyporus barbaeformis* (Poria, Sacc.). The habit of growing on smooth green bark is similar to that of *Septobasidium retiforme* (Berk. & Curt.) Pat. and *S. frustulosum* (Berk. & Curt.) Pat., the latter being very common on the bark of young ash in Mexico and is considered injurious.

Poria papyracea is easily distinguished from all other members of the genus by its broad elongate elliptic or cylindric guttulate spores with the appearance of peculiar longitudinal striations or reticulate echinulations; the spores average 15–16 × 5.9–8.5 μ.—James R. Weir.

REPORT OF THE FOURTEENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The fourteenth annual meeting of the Society was held in the Main Building of the Massachusetts Institute of Technology, Cambridge, Massachusetts, December 27–30, 1922, in conjunction with the American Association for the Advancement of Science and affiliated scientific societies. President E. C. Stakman of Minnesota presided and about ninety-five members were present. The headquarters of the Society were at the Parker House, Boston, Massachusetts.

There were seventy-nine papers on the regular program, abstracts of which were printed in the January number of Phytopathology. Advance separates of the abstracts were distributed for use at the meetings.

There were three joint sessions with other societies. On Wednesday afternoon, December 27, occurred the annual meeting of Section G of the American Association for the Advancement of Science. At that meeting Dr. Mel. T. Cook, retiring Vice President of Section G, gave an address entitled "The Origin and Structure of Plant Galls." This address was followed by a symposium on Sterility of Plants, papers being given by A. B. Stout on Physiology of Incompatibility, B. M. Davis on Pollen and Seed Sterility in Hybrids, E. M. East on Genetical Aspects of Self and Cross Sterility, and M. J. Dorsey on Sterility in Relation to Horticulture. On Saturday morning, December 30, a joint session was held with the American Association of Economic Entomologists, the subject being a symposium on Plant Quarantines. Papers were presented by C. L. Marlatt on The When and Why of Plant Quarantines, W. A. Orton and R. K. Beattie on Scientific Basis of Foreign Plant Quarantines, W. A. McCubbin on Factors Contributing to Success in Domestic Quarantines, Wilmon Newell on Tropical and Sub-tropical Quarantines, and Lee A. Strong on Western Views on Plant Quarantines.

On Thursday morning the American Phytopathological Society joined the Physiological Section of the Botanical Society of America in a symposium on Mosaic Diseases of Plants, at which fourteen papers were presented. The meeting was noteworthy in that four papers reported the finding of definite bodies or organisms in the tissue of plants affected with mosaic. L. O. Kunkel reported his further studies on the intracellular bodies associated with mosaic of *Hippeastrum equestre* and corn in Hawaii. H. H. McKinney, Sophia H. Eckerson and R. W. Webb gave two papers dealing with the intracellular bodies associated with mosaic of *Hippeastrum johnsonii* and also with the rosette disease of wheat, while Ray Nelson, in a paper illustrated by beautiful photomicrographs, reported the finding of definite flagellate protozoans constantly associated with leaf roll of potato and with mosaic of bean, clover and tomato. It seems probable that the intracellular bodies reported by Kunkel and by McKinney, Eckerson and Webb are also protozoans. Further studies in which the best modern protozoan technique is used should yield results of the greatest importance in adding to our knowledge of the cause of this type of disease. Without doubt this symposium marks an important milestone in the progress of plant pathology.

The annual dinner of the Society was held on Friday evening, December 29, in the Walker Memorial Building of the Massachusetts Institute of Technology and was attended by one hundred and sixteen pathologists and botanists.

The following officers were elected:

President, G. R. Lyman, West Virginia College of Agriculture, Morgantown, W. Va.

Vice President, F. D. Fromme, Virginia Polytechnic Institute, Blacksburg, Va.

Secretary-Treasurer, R. J. Haskell, U. S. Department of Agriculture, Washington, D. C.

Councilor for two years, M. F. Barrus, New York State College of Agriculture, Ithaca, N. Y.

Councilors for one year (chosen by the Divisions of the Society), W. P. Fraser, University of Saskatchewan, Saskatoon, Saskatchewan, representing the Canadian Division; F. D. Heald, State College of Washington, Pullman, Wash., representing the Pacific Coast Division; and L. R. Hesler, University of Tennessee, Knoxville, Tenn., representing the Southern Division.

Members of the Editorial Board of Phytopathology (chosen by the Council of the Society): Editor for one year, N. J. Giddings, West Virginia University, Morgantown, West Virginia; Associate Editors for three years, J. G. Leach, College of Agriculture, University Farm, St. Paul, Minnesota; W. D. Valleau, University of Kentucky, Lexington, Kentucky; R. D. Rands, U. S. Department of Agriculture, Washington, D. C.; W. A. McCubbin, Bureau of Plant Industry, Harrisburg, Pennsylvania; Business Manager for one year, R. J. Haskell, U. S. Department of Agriculture, Washington, D. C.; Advertising Manager for one year, R. G. Pierce, U. S. Department of Agriculture, Washington, D. C.

Member of the Editorial Board of American Journal of Botany for three years (chosen by the Council): Donald Reddick, Cornell University, Ithaca, N. Y.

Representative on Board of Control of Botanical Abstracts for four years (elected by the Society): E. C. Stakman, University of Minnesota, University Farm, St. Paul, Minnesota.

Representative on the Council of the American Association for the Advancement of Science for one year (chosen by the Council): G. P. Clinton, Agricultural Experiment Station, New Haven, Connecticut, and W. A. Orton, U. S. Department of Agriculture, Washington, D. C.

Members of the Advisory Board (chosen by the Council): C. W. Hungerford, University of Idaho, Moscow, Idaho, for three years to succeed H. P. Barss as Commissioner for the West; L. R. Hesler, University of Tennessee, Knoxville, Tennessee, for three years to succeed J. A. Elliott as Commissioner for the South; L. R. Jones, University of Wisconsin, Madison, Wisconsin, for three years, and M. F. Barrus, Cornell University, Ithaca, N. Y., for two years, to succeed L. R. Jones and E. M. Freeman, respectively, as Commissioners at Large.

REPORT OF THE TREASURER FOR 1922

Receipts:

Balance from 1921	$1,009.90
Annual dues	3,757.86
Subscriptions received with annual dues	5.00
Contribution to Phytopathology deficit received with annual dues	3.00
Excess dues	5.60
Interest on checking account	36.95
Exchange on foreign membership checks	.94

Sales received in checks with annual dues	14.50	
Subscriptions to the Oberly Memorial Fund received with annual dues	47.48	
		$4,881.23
Expenditures:		
Member subscriptions transferred to Phytopathology	$1,792.00	
Secretarial work	250.43	
Stationery, stamped envelopes, printing	215.78	
Subscriptions received with dues transferred	5.00	
Contribution to deficit received with dues	3.00	
Sales received with dues	15.00	
Postage stamps	7.50	
Excess dues returned	5.75	
Duplicate dues returned	4.00	
Secretary-Treasurer's travel and miscellaneous expenses	126.77	
Supplies, rubber stamps, etc.	7.22	
Checks returned by bank	16.25	
Cost of Russian cable	4.80	
Error in discount	.95	
Amount transferred to sinking fund for investment	1,100.00	
		$3,554.45
Balance		$1,326.78
Amount of receipts for 1923 and 1924 included above	$1,027.75	
Sinking fund:		
Balance due for 1921	$20.58	
Balance due for 1922	5.00	25.58
		$1,053.33
Actual balance for the year 1922		$273.45

In accordance with directions given at the Toronto meeting, the Secretary, in sending out the notices of annual dues for 1923, requested each member to add twenty-five cents to his check as a personal contribution to the fund for the Eunice R. Oberly Memorial Prize. Many members are responding to this request, and $47.48 have already been received. Full report must be deferred until next year.

On December 20, 1922, the Society had 553 members in good standing:—89 life sustaining and 464 regular, as opposed to 539 in 1921, 495 in 1920, and 452 in 1919. Therefore it is seen that the Society is maintaining a steady growth. Thirty-three candidates were elected to membership.

REPORT OF THE BUSINESS MANAGER OF PHYTOPATHOLOGY FOR 1922

Receipts:	
Balance from 1921	$1,728.14
Member subscriptions transferred from Society	1,792.00

Subscriptions		2,013.00	
Sales		339.15	
Advertising, 1921		322.54	
Advertising, 1922		336.53	
Contributions to Phytopathology deficit		11.24	
Interest on invested sinking fund		120.00	
Balance due sinking fund to June 1		1,000.00	
			$7,662.60

Expenditures:

Manufacturing Phytopathology:				
Vol. XI, No. 8	$343.43			
Vol. XI, No. 9	234.92			
Vol. XI, No. 10	307.09			
Vol. XI, No. 11	268.00			
Vol. XI, No. 12	308.84			
Vol. XI, Index	148.72	$1,611.00		
Vol. XII, No. 1	385.41			
Vol. XII, No. 2	376.13			
Vol. XII, No. 3	394.58			
Vol. XII, No. 4	378.61			
Vol. XII, No. 5	295.12			
Vol. XII, No. 6	385.29			
Vol. XII, No. 7	185.05			
Vol. XII, No. 8	367.35			
Vol. XII, No. 9	364.56			
		$3,132.10		
		$4,743.10	$4,743.10	
Miscellaneous Journal expenses (Dix lists, etc.)			$86.85	
Secretarial work			74.28	
Supplies, miscellaneous			7.10	
Rebate for parts of journal not supplied			4.00	
Printing bill heads			10.00	
Postage			33.18	
Duplicate subscription returned			5.00	
Miscellaneous expenses of Business Manager			39.45	
Miscellaneous expenses of Editor-in-Chief			18.24	
Checks returned by bank			10.75	
Check to reimburse G. R. Lyman for amount paid from his personal account in error			5.00	
Sinking fund invested with accrued interest			1,002.72	
Refund on cancelled order			1.65	
				$6,041.32
Balance				$1,621.28
Amount of 1923 subscriptions included in the above receipts				303.15
Actual balance for 1922				$1,307.63

Sinking Fund:

Amount invested in first mortgage notes	$3,000.00	
Amount invested at 4% time deposit for 6 months	100.00	
Balance in Society treasury due sinking fund 1921–22	25.58	
		$3,125.58

At the Chicago meeting two years ago the business manager reported an indebtedness of Phytopathology amounting to $2,179.72. At that time the Society appropriated $575.00 from its treasury and the members voluntarily contributed $1,059.72 toward paying this deficit, making a total of $1,634.72. There still remained an indebtedness of $545.00, which Phytopathology had to carry as it entered on the new plan of operation in January, 1921.

Two years have now elapsed under the new plan of operation, which included a change of printers, the collection of subscriptions by the business manager, and the appointment of an advertising manager to handle advertisements,—both subscriptions and advertising having been handled previously on a percentage basis by the Williams & Wilkins Company, the former publishers. During the past two years the receipts for both subscriptions and advertisements have increased materially and this increased income, together with reduced expenses, has enabled Phytopathology to overcome the $545.00 deficit, to increase the number of printed pages per year, and to accumulate a balance, so that if Phytopathology were to suspend publication at the close of 1922 and all bills payable and receivable were liquidated there would be a clear balance of $892.81. The official journal of the Society has passed its financial crisis safely and is now on firm ground.

An auditing committee consisting of F. D. Fromme and A. T. Evans was appointed to examine the accounts of the treasurer and business manager. This committee found the accounts correct and the reports were adopted.

REPORT OF EDITOR-IN-CHIEF OF PHYTOPATHOLOGY

The printers' strike caused considerable delay in publishing the earlier numbers of Phytopathology during 1922. In spite of this fact, the December number, including the index of the twelve numbers, appeared in January. During 1923 the numbers should come out about on time. It will be noted that several papers somewhat longer than usual have been published during 1922. The editor adopted the policy of accepting or rejecting papers wholly on their merit, regardless of length. There have been published in all during 1922, 597 pages of text, 113 text figures, and 36 full page plates. The abstracts of papers presented at the meetings of the three Divisions, as well as at the Toronto meeting of the Society, have been published during the year. These abstracts, of which there were 145, required 51 pages of text.

REPORT OF THE RETIRING REPRESENTATIVE ON THE BOARD OF CONTROL OF BOTANICAL ABSTRACTS

Dr. Donald Reddick, the retiring representative of the Society, served for two years as Chairman of the Board of Control, has been a member of the Executive Committee for four years and recently has assumed business management of the journal. He submitted the following report:

The problems of the Board have been numerous and varied. The financial problem, however, has and still does overshadow all others. Much time has been given to this all-important phase of the work.

Aside from the more general duties on such a Board your representative has attempted to further the interests of the Society in every legitimate way. He, himself, acted as editor for the section *Pathology* for a short time. An effort was made to liberalize the field of this section by including essential work in general pathology. When the collecting of abstracts was placed in the hands of a bibliographer and the "journal basis" adopted it proved rather difficult to find a suitable plan for accomplishing this. The problem was passed on to Dr. G. H. Coons who made some progress with it, but Doctor Coons was forced to resign and Mr. F. V. Rand now labors with it. The Board has given very great latitude to the editors in the development of their respective sections. It is to be hoped that Mr. Rand will find a way of developing the section on Pathology to its greatest usefulness.

The most regrettable feature of the work has been the general lack of constructive criticism, or, indeed, of criticism of any sort, from members of the Society. In anticipation of just this condition, among others, the Board adopted the working rule that members of the Board shall not be eligible for immediate reelection. The Board, *per se*, cannot enforce such a rule, but if the constituent societies can be induced to osberve it, the Board can be maintained as a democratically constituted body and by proper elections our Society can be assured that our best talent eventually will be directed to making *Botanical Abstracts* the best and most complete publication in existence for abstracting pathological articles.

The willingness of members of the Society to support *Botanical Abstracts* has been most gratifying. The response to every appeal for help has been most satisfactory. At least 80 of our members serve as collaborators, many of our members own bonds of the corporation and an unusually large proportion of our members subscribe for the journal.

UNION OF AMERICAN BIOLOGICAL SOCIETIES

At the Toronto meeting this Society gave preliminary consideration to this subject and designated Donald Reddick and G. R. Lyman as its representatives at a proposed inter-society conference to consider a plan of federation. This conference was held in Washington last spring and all the representatives of the biological societies present were unanimously in favor of forming a federation. Therefore, an executive committee was appointed to draft a constitution and to work out the details of organization. The report of this executive committee, giving the wording of the proposed constitution, was printed in Science (Science LVI: 359–361, Sept. 29, 1922) and reprints of this article were distributed to all members of the American Phytopathological Society in advance of the Boston meeting. Membership in the proposed union is by societies, not by individuals. Each member society retains complete autonomy and is entitled to two representatives on the Council of the Union. The principal primary purpose of the Union is the promotion of biological publications.

After consideration, the Society voted to accept membership in the proposed Union of American Biological Societies and requested the Council of the Society to select the two representatives on the Council of the Union. Donald Reddick and Perley Spaulding were named by the Council as the representatives of the American Phytopathological Society.

REPORT OF THE ADVISORY BOARD

The Advisory Board reported to the Council through its Chairman, C. R. Orton. The report was referred to the Society by the Council and was adopted as follows:

Summer conference:—The fourth annual summer meeting of the Society was held in Delaware, New Jersey, and Philadelphia and vicinity, being devoted to the diseases of vegetables and the problems of market pathology. The meetings were attended by sixty-five scientists besides a considerable number of growers and others interested in marketing problems. Members were present from the Philippine Islands, Ontario, Quebec, Nova Scotia and twelve states. There were present as guests of the Society, Dr. I. B. Pole-Evans, Pretoria, South Africa; Senor Alfonso Madariaga, Director of Agriculture, San Jacinto, Mexico; Dr. C. Boyle, Dept. of Agriculture, Dublin, Ireland; Dr. Seiya Ito, Hokkaido Imperial University, Sapporo, Japan; Dr. Takewo Hemmi, Kyoto Imperial University, Kyoto, Japan; Dr. D. N. Borodin, Russian Agricultural Bureau, 136 Liberty Street, New York City; Dr. Rudolf Kuraz, Agricultural Attache, Czechoslovak Legation, Washington, D. C.; Mr. Carlos Vallejo, Agricultural Attache, Argentine Legation, Washington, D. C.; and Mr. R. J. Noble, Dept. of Agriculture, New South Wales, Australia. A more extended report of the conference, prepared by the Secretary, Dr. R. J. Haskell, has already been published in Phytopathology.

Phytopathological project list:—At the Toronto meeting it was decided to discontinue this list as an annual project. There is some doubt whether such a list is worth the time and effort necessary to prepare it. By request of the Advisory Board, a vote of the Society was taken at Boston to ascertain whether this list should be continued, and a large majority of those present voted that it is inadvisable at present to continue the preparation of such lists.

Phytopathological Institute:—Dr. E. C. Stakman was chosen leader of this project at the Toronto meeting. Certain phases of co-operative researches on mosaic have been undertaken at the Thompson Institute, and at the summer conference in Philadelphia Dr. William Crocker presented to the Advisory Board the plans for that Institute and requested the counsel of the Advisory Board regarding the development of work at the Institute along phytopathological lines. Everything possible will be done to facilitate the development of such work at the Thompson Institute.

Some progress has been made in eliciting the interest of officials in the U. S. Department of Agriculture toward offering their facilities for co-ordinating certain types of research work, and providing space and other facilities for visiting scientists.

Cooperation with the National Research Council:—The Advisory Board functions as the Committee on Co-operation in Phytopathology of the National Research Council. The Chairman is also a member of the Division of Biology and Agriculture, succeeding Dr. G. R. Lyman whose term of office expired June 30, 1922. In this capacity the Board has fostered a number of co-operative projects. During the past year special attention has been given the Arthur rust project, dusting of fruits and vegetables, seed borne diseases, use of sulphur for control of potato scab, sulphur investigations, nickel investigations, Scaleeide investigations, and cereal seed disinfections. All but the first mentioned are co-operative with the Crop Protection Institute.

The Rust project was initiated September 1 through the joint efforts of the Division of Biology and Agriculture of the National Research Council; the Office of Cereal Investigations, U. S. Department of Agriculture; the officers of the Indiana Agricultural Experiment Station, the Pennsylvania State College, and the Virginia Polytechnic Institute; and the Arthur Committee. Laboratory space and facilities, a clerical graduate assistant, library space, and the time of certain investigators has been provided by the Indiana Agricultural Experiment Station; travelling expenses of co-operators are being provided by the National Research Council; an honorarium for Dr. Arthur was provided by the Office of Cereal Investigations, U. S. Department of

Agriculture; and the Pennsylvania State College and Virginia Polytechnic Institute have agreed to grant leave of absence with pay to F. D. Kern and C. R. Orton of the former and F. D. Fromme of the latter to aid Dr. Arthur in the preparation of the manuscript of a volume on Plant Rusts. The Indiana Experiment Station has also agreed to grant time to H. S. Jackson and E. B. Mains for a similar purpose. The co-operators on this project met at Lafayette in June and drew up a tentative outline on Plant Rusts and steady progress has since been made by Dr. Arthur with the assistance of the graduate student provided.

The dusting project has been under the leadership of F. D. Fromme, N. J. Giddings and P. J. Parrott during the past year. Co-operative tests have been conducted in several states and some Canadian provinces, and some noteworthy results obtained.

The project on seed borne diseases has been handled in co-operation with the Crop Protection Institute under the leadership of a special committee composed of M. F. Barrus, M. T. Munn and the Chairman of the Advisory Board. A preliminary list of seed borne diseases has been prepared. The subject was presented by C. R. Orton before the American Seed Trade Association at their annual meeting in Chicago, June 22. Action has been taken by the Association of Official Seed Analysts leading to the practice of reporting disease indications upon the certificate as a part of the service rendered. Good progress is being made on this project and assurance has been given that the matter will receive special attention by the Executive Committee of the American Seed Trade Association. The committee is to be continued.

The project on use of sulphur for the control of potato scab has been under the leadership of C. R. Orton and G. H. Coons.

The sulphur investigations have been under the leadership of a committee composed of G. H. Coons, P. J. Parrott and C. R. Orton. Fifteen thousand dollars have been subscribed during the past year by three sulphur producing companies for fundamental researches upon the effect of elemental sulphur upon fungi and insects. Two investigators have been secured, one of whom is working under the direction of Dr. B. M. Duggar at the Missouri Botanical Garden and the other is at work under the joint leadership of Professor Herbert Osborne at Ohio State University and Dr. P. J. Parrott at the New York Agricultural Experiment Station. Important results have already been secured and this project is well established.

The nickel investigations project is of a preliminary nature and no attempt has been made to expand it beyond these preliminary tests up to the present time. Co-operative tests have been made in Delaware, Pennsylvania, Minnesota, Quebec, and Ontario during the past year.

The B. G. Pratt Company has recently signed a contract pledging forty-five hundred dollars annually for a period of not less than three years for the purpose of investigating the effects of Scalecide upon fire blight and upon the rate of growth of apple and pear trees. This project is under a committee composed of C. R. Orton, H. W. Anderson and P. J. Parrott. The funds are to be made available January 1, 1923, and investigations will be started this spring.

The cereal seed treatment project under the leadership of C. R. Orton, E. C. Stakman and E. B. Lambert, was initiated in the spring of 1922 in several states and Canadian provinces. The copper carbonate has been furnished through the Crop Protection Institute and tested out on wheat and oats along with copper sulphate and formaldehyde. The results to date have been collected in mimeographed form.

"Science Service" is in need of promotion by the Society and to this end the Secretary, Dr. Haskell, has been giving it personal attention. The Advisory Board will endeavor to secure the interest of other workers.

Crop Protection Institute:—Two members of the Advisory Board, G. H. Coons and C. R. Orton, have served during the past year upon the Board of Governors of the Crop Protection Institute. It seems important that these two agencies should be co-ordinated by the continuance of this policy. A considerable amount of time has been devoted by the various members of the Board of Governors to the Crop Protection Institute and this must continue throughout the early years of its development. C. R. Orton, whose term expired at the Boston meeting, was elected to succeed himself for a three year's term. F. D. Fromme is the third representative of the Society upon the Board of Governors.

REPORTS OF COMMITTEES

The Committee on Standardization of Biological Stains:—Dr. R. H. Colley made a brief report on data obtained from a test questionnaire sent to members of the Society. The conclusions reached were that most of the laboratories of all plant pathology are still supplied with European stains and that success with American stains depends largely upon the skill of the operator in handling new products. Members of the Society interested in the work of standardization of American biological stains were urged to communicate personally with Dr. H. J. Conn, Geneva, N. Y. The report was accepted and the committee discharged.

The Committee on the F. Kölpin Ravn Fellowship reported through its chairman, Dr. L. R. Jones, that further inquiries have been made looking toward the endowment of a Fellowship, but that no definite progress could be reported as yet. On recommendation of the committee the report was accepted and the committee discharged. On motion of Dr. Jones it was voted that the Council appoint a new committee to carry on this work, and such a committee was appointed, consisting of R. Kent Beattie, A. G. Johnson and C. L. Shear.

The Committee on Bacterial Nomenclature:—Dr. Erwin F. Smith, chairman of this committee, stated that no formal report could be made at the Boston meeting. The committee was continued.

PHYTOPATHOLOGICAL RESEARCH IN THE TROPICS

W. A. Orton reported on this subject as chairman of a special committee of the National Research Council. This committee has been working in co-operation with the Advisory Board and has developed plans looking toward the incorporation of an organization to be called "The Tropical Phytopathological Institute." This institute is designed to provide an efficient and reliable organization for the advancement of knowledge of the native plants and cultivated crops of the tropics, including their diseases and other pests. The plans of the committee were approved in principle by the Society and the committee was instructed to proceed with the development of the plans and to secure the endorsement of the National Research Council.

RESOLUTIONS

A committee on resolutions, consisting of L. M. Massey, F. L. Drayton and H. W. Anderson, was appointed by the president. This committee reported the following resolutions, which were unanimously adopted.

1. The American Phytopathological Society wishes to express to Dr. W. H. Weston and the other members of the local committee on arrangements, to the authorities of the Massachusetts Institute of Technology, and to the municipal authorities of Boston and Cambridge its sincere appreciation of the courtesies and hospitality extended to its members throughout the meetings of the Society.

2. The American Phytopathological Society wishes to place on record its appreciation of the liberal assistance given by the National Research Council to the Board of Control of Botanical Abstracts which has made possible the continued publication of this journal.

3. In view of the efficient and untiring services rendered by our retiring secretary and treasurer, Dr. G. R. Lyman, at great personal sacrifice, the members of the American Phytopathological Society assembled at their annual meeting in Boston wish to express their sincere gratitude. As business manager of Phytopathology, Doctor Lyman, by his unceasing efforts, has rendered plant pathologists a lasting service by maintaining the journal at a high standard of efficiency.

4. The American Phytopathological Society in annual convention assembled expresses its deep regret at the passing on October 29, 1922, of Dr. Elias J. Durand, professor of botany at the University of Minnesota. Dr. Durand has been active for many years as a teacher of botany and as an investigator, especially in the field of mycology. The Society extends sympathy to his many friends, especially to his family and to his co-workers in the University of Minnesota.

5. It is with profound sorrow that we, the members of the American Phytopathological Society in annual conference assembled have to record the death, on June 13, 1922, of Frederick C. Werkenthin, assistant professor of botany at the Iowa State College of Agriculture, Ames, Iowa. Professor Werkenthin was most successful as a teacher, commanding the respect and confidence of students and faculty at all of the institutions where he served. He showed unusual promise as an investigator and during his brief scientific career he made a number of noteworthy contributions to botanical science. On account of this, our mutual loss, the American Phytopathological Society wishes to express the deepest and most sincere sympathy of its members to the family, colleagues and friends of our departed brother.

FOREIGN MEETINGS

At the annual dinner, Dr. W. A. Orton presented an invitation received from Dr. H. M. Quanjer for the American Phytopathological Society to be represented at the International Conference of Phytopathology and Economic Entomology in Holland, June, 1923. The conference will convene at Wageningen on Sunday, June 24, and will adjourn June 30 at The Hague. Various important agricultural districts of Holland will be visited and attention will be given to diseases of potatoes, fruit and truck crops, flower bulbs and ornamentals. President Stakman also spoke briefly of the Pasteur Centennial celebration in the form of a Scientific and Industrial Exposition of Hygiene at Strasbourg, June to October, 1923, which Americans are urged to attend and to which they are invited to send exhibits. The Society expressed its appreciation of these invitations and instructed the Council to do all in its power to promote the attendance of several of our members as accredited representatives of the Society.

MISCELLANEOUS BUSINESS

The secretary's report of the thirteenth annual meeting held at Toronto, Canada, December 27–31, 1921, was adopted without correction as published in No. 4, volume 12 of Phytopathology.

The Society voted to hold its fifteenth annual meeting at Cincinnati, Ohio, December 27, 1923, to January 2, 1924, in conjunction with the American Association for the Advancement of Science and other biological societies.

At the Toronto meeting President Reddick was authorized to send a contribution of $25.00 in the name of the Society to a memorial in Rome, to Dr. Giuseppe Cuboni, late

Director of the Raele Stazione di Patologia Vegetale. Dr. Reddick reported that the the principal phytopathological centers in America had been asked for contributions to this fund and the response had been so generous that a total of $36.50 was received. Of this amount $25.00 was sent to Rome and the balance, $11.50, was added to the Oberly Memorial fund. Dr. Reddick read to the Society the letter of appreciation of this gift received from Professor Traverso.

At the annual meeting of Plant Disease Survey collaborators it was voted to recommend to the American Phytopathological Society that a committee of the Society be appointed to carry on a campaign of education looking to more adequate financial support of the Plant Disease Survey. The Society approved this recommendation and directed the president to appoint the chairman of such a committee who should be authorized to select the other members of the committee. President Stakman appointed Dr. N. J. Giddings as chairman of this committee.

At the annual dinner the matter was discussed of sending Phytopathology to pathological workers in certain European countries where the exceedingly unfavorable rates of exchange make subscription to the journal impossible. Dr. Stakman and Dr. Spaulding, who have recently returned from European trips, spoke of the deplorable lack of current pathological literature in the libraries of our colleagues in these countries and urged members of the Society to adopt a more liberal policy in sending their separates abroad. After discussion, the members present voted unanimously to raise money to defray the expense of sending Phytopathology to foreign pathologists. The hat was passed and $105.00 in cash was collected. It was voted that this money be used to send Phytopathology to institutions and to certain individuals selected by the Council. It was further voted that the Council be authorized, after investigation, to complete gratis the files of Phytopathology in certain institutions, especially in Austria, Hungary, Germany and Russia, where in the judgment of the Council complete sets will be of greatest value.

G. R. LYMAN, *Secretary.*

The March number of Phytopathology was issued March 13, 1923.